

Signs of Life:

THE GROWTH OF BIOTECHNOLOGY CENTERS IN THE U.S.

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Increasingly, regions throughout the country are exploring the possibilities the biotechnology industry offers as an economic development engine to entire metropolitan areas. But what does it take for a metropolitan area to become a biotech center? This Brookings Institution report identifies existing biotechnology centers and describes the factors that have gone into their successes.

The biotechnology industry is built on fundamental breakthroughs in the understanding of genetic and biological processes to develop new means of diagnosing and treating disease. Biotechnology is at the heart of an important and fast-growing new sector of the U.S. economy, and as the industry expands, it has become a focal point of many local, regional, and state economic development strategies. The present report is a survey of biotechnology research and commercialization in the 51 largest U.S. metropolitan areas. By providing an examination of the industry, its location, and the key ingredients needed to foster its development, the report may help to inform regions across the country that are hoping to capture a share of biotechnology growth.

Defining Biotechnology

Biotechnology is the application of biological knowledge and techniques pertaining to molecular, cellular, and genetic processes to develop products and services. The biotechnology industry, as it defines itself, consists of firms established to develop this knowledge and to exploit it commercially. Biotechnology has potential applications in a wide array of industries. The largest category of biotechnology applications is in health and medicine: diagnosing, treating, and in some cases preventing disease. Standard and Poor's estimates that human diagnostics and therapeutics account for 95% of biotechnology revenues. Because diagnostics and therapeutics constitute the largest segment of the

biotech industry, the report focuses on these applications of biotechnology.

This report looks at both pharmaceutical firms, defined as manufacturers and makers of drugs, and a wide variety of related products; and biotechnology firms, defined as those firms founded for the purpose of applying biological knowledge and techniques to develop products and services.

The pharmaceutical industry and the biotechnology industry have a number of important characteristics that distinguish them from each other and from other industries. Biotechnology research firms tend to be small and fairly recently established and to devote most of their resources to research and development. Pharmaceutical firms, in contrast, are much larger and much older and have well-developed manufacturing and marketing operations, often worldwide in scale. Firms tend not to move between these two categories — small biotech firms, even extraordinarily successful ones, do not grow into large pharmaceutical firms. Instead, biotech research firms tend to sell or license their technologies to larger pharmaceutical firms, or to form joint ventures with them, or to sell them their entire companies.

Biotechnology Clusters

The U.S. biotechnology industry is concentrated largely within nine metropolitan areas: Boston, Los Angeles, New York, Philadelphia, Raleigh-Durham, San Diego, San Francisco, Seattle, and

Washington/Baltimore. These nine areas account for more than three-fifths of all National Institutes of Health (NIH) spending on research for slightly less than two-thirds of all biotechnology-related patents. Biotechnology commercialization is even more concentrated within these areas: more than three-fourths of all biotech firms founded in the past decade with 100 or more employees are in one of these nine areas; the same areas account for eight of every nine dollars in venture capital for biopharmaceuticals and for 95% of the dollars in research alliances (research and development contracts and funding arrangements between pharmaceutical and biotech firms).

Pharmaceutical Centers

New York and Philadelphia are the traditional centers of the U.S. pharmaceutical industry. These two regions are relatively stronger in research than they are in commercialization (an interesting contrast with Boston and San Francisco, which have much higher indices of commercialization than of research). New York's research activity is about eight times the U.S. mean, and its commercialization about six times the U.S. average. Similarly, Philadelphia has nearly four times the U.S. mean level of research activity and about double the U.S. mean level of commercialization. Strikingly, although both regions have important concentrations of biotech firms (36 such firms with 100 or more employees in New York and 10 in Philadelphia), both have actually lost share of commercial biotechnology activity as measured by new-firm formation vis-à-vis their performance during the 1980s.

Biotech Leaders

By almost all measures, Boston and San Francisco stand out as the strongest biotech regions in the United States. Both were home to pioneering firms in the biotechnology industry in the 1970s and have continued to build on their first-mover advantages and on their solid research base. Both of these metropolitan areas are strong in biotechnology research but truly excel in commercialization. These regions have about five times as much research activity as the U.S. average but about 10 times as much biotech commercialization. Boston gets more NIH funding (about \$1.4 billion in 2000) than any other metropolitan area in the country, San Francisco and Boston have three of the nation's 20 top-ranked medical research institutions, and each region accounted for more than 3,000 biotechnology-related patents in the past decade. These two regions also account for a majority of the value of research alliances, and each has generated more than 60 new biotech companies in the past decade.



Biotech Challengers

Raleigh-Durham, Seattle, and especially San Diego have seen rapid growth in commercial biotechnology activity in the past decade. These regions have been particularly successful in generating new firms and in securing venture capital and research contracts with pharmaceutical firms. Each has an above-average level of research activity (1.6 times to 2.7 times the U.S. mean), but all are relatively stronger in commercialization than in research. San Diego is clearly the strongest of the three, having attracted \$1.5 billion in venture capital and \$1.6 billion in alliance funding and having created 38 new firms in the past decade; San Diego now has 31 biotech firms with 100 or more employees. Seattle and Raleigh-Durham have garnered about \$400 million each in venture capital during the decade, resulting in 11 new firms in Seattle and 46 new firms in Raleigh-Durham.

Other Biotechnology Centers

Two other regions — Washington/Baltimore and Los Angeles — represent special cases. Each of these regions has a formidable concentration of research institutions and some particularly strong firms, and each region draws on special advantages. The Washington/Baltimore metropolitan area has an important concentration of biotechnology firms and is aided by the local presence of the NIH and the Food and Drug Administration. Los Angeles is the second-largest metropolitan area in the United States (after New York) and is the location of the

Table 1: Biotechnology Center Statistics

Top 9 Biotechnology Centers	Biological Science PhDs				NIH Funding to Top 100 Cities, 2000	
	Life Scientists 1998	Institutions Granting PhDs	#of PhDs Granted	Top-Ranked Research Univ.	Amount	Share
		1999	1999	1982		
Boston CMSA	4,980	13	355	3	1,422,875,474	12%
San Francisco CMSA	3,090	3	215	3	703,529,044	6%
San Diego MSA	1,430	3	82	1	680,954,889	6%
Raleigh-Durham MSA	910	3	166	1	469,119,754	4%
Seattle CMSA	1,810	1	68	1	504,375,867	4%
New York CMSA	4,790	20	519	3	1,382,530,715	12%
Philadelphia CMSA	1,410	7	139	1	596,195,344	5%
Los Angeles CMSA	2,450	7	218	2	594,666,368	5%
Washington-Baltimore CSMA	6,670	12	241	1	952,835,848	8%

Sources: National Institutes of Health 2001, National Science Foundation, 2001

headquarters of Amgen, the nation's largest biotech firm. Both regions have substantially stronger bases in research (almost four times the U.S. mean for Washington/Baltimore and more than double the U.S. mean for Los Angeles) than they have in commercialization (slightly more than double the U.S. mean for Washington/Baltimore and about one and a half times the U.S. mean for Los Angeles). Both regions have a relatively large base of biotechnology activity, but neither has attracted as much venture capital financing as have the three biotech challengers.

Characteristics of Biotech Centers

Biotechnology is highly concentrated within those metropolitan areas that combine a strong research capacity with the ability to convert research into substantial commercial activity. The geographic distribution of research activities and the contrasting distribution of private investment and new-firm formation illustrate how both these ingredients need to be combined in order to generate a thriving industry cluster.

Biotechnology Research

Almost every discussion of the biotechnology industry begins with reference to the fundamental role of biomedical research. Much of this research has been undertaken at medical schools and other medical research institutions with the substantial assistance of public funding from the NIH. The insights from such research are the basis of this industry, and thus the initial step in understanding the geography of biotechnology is to examine the location of research institutions and research scientist.

Biological-Science Work Force and Education

As a knowledge-based industry, biotechnology is highly dependent on the availability of specially trained professionals, particularly research scientists and technicians. A good indicator of the relative supply of highly trained individuals is the number of life sciences Ph.D. degrees conferred annually in a metropolitan area. In addition, because Ph.D. students are typically engaged in ongoing academic research as part of their degree programs, the number of life sciences Ph.D. degrees conferred annually in a metropolitan area is also an indirect measure of research capacity. As Table 1 shows, the New York metropolitan area granted the most life sciences Ph.D.'s in 1999, followed by Boston. Washington/Baltimore, Los Angeles, and San Francisco each conferred more than 200 life science Ph.D. degrees that same year. The quality of medical research and education is also likely to have a bearing on the development of a biotechnology industry. In particular, medical schools with the best reputations may be relatively more effective in recruiting the best faculty and students and in attracting funding for research activities. Sixteen of the country's top 20 institutions are located in the nine biotechnology centers (Table 1).

Research Funding by the National Institutes of Health

The federal government's generous and growing support for medical and biological research helps seed the creation of new ideas. A wide variety of federal agencies provide funding for research and training related to medicine, health, and biotechnology, but the largest single funder of such research is the National Institutes of Health. Total NIH spending

for research has more than doubled during the 1990s, from about \$6.5 billion in 1991 to more than \$13 billion in 2000. Funding by NIH is disbursed to research programs throughout the nation, but it goes disproportionately to areas with a large, well-established research infrastructure. Table 1 illustrates the distribution of overall NIH research funding by metropolitan area for 2000. The greatest shares go to Boston and New York.

Biotechnology Commercialization

Which metropolitan areas are leading in translating biomedical research into commercial biotechnology activity as measured by investment, new-product development, and the formation and success of biotechnology firms? To answer the question, a series of measures was developed that focus on capital investment in biotechnology and on the number and size of biotechnology firms.

Venture Capital Investments. Venture capital is a good leading indicator of the development of ideas into potential businesses. Venture capital investment in biopharmaceutical firms is concentrated within just a few metropolitan areas. Boston and San Francisco account for a majority of all venture capital investments in the 51 largest metropolitan areas: \$4.9 billion of the \$9.7 billion invested between 1995 and 2001. The availability of venture capital is contingent in part on the presence of local venture capital firms. Because venture capital investing requires making risky judgments about the likelihood of commercial success of particular research ideas, venture capitalists must have particular technical expertise in appraising biotech business plans. In addition, venture capital investment firms attempt to minimize their risks and to increase the probability of success of their investments by playing an active role in the management of the firms in which they invest. Because these tasks tend to be time consuming, venture capitalists strongly prefer to invest in and work with firms located near their offices.

Alliances and Research Contracts. A major source of funding for biotech firms developing new products consists of research and development contracts and equity funding arrangements with major pharmaceutical companies. The flow of research contracts from pharmaceutical funds to biotechnology firms is a strong indicator of the location of commercially promising research activities. Four metropolitan areas account for more than four-fifths of the value of all research contracts: Boston (\$5.1 billion), San Francisco (\$2.8 billion), San Diego (\$2.7 billion), and New York (\$2.6 billion). Only two other metropolitan areas attracted more than half a billion dollars in such contracts: Washington/Baltimore (\$600 million) and Seattle (\$700 million).

Initial Public Offerings. Biotechnology firms can also raise money to finance research and development activities by selling stock in public markets. Going public requires undertaking an initial public offering (IPO) prior to which the firm must undergo a rigorous process of review and disclosure. The costs of undertaking an IPO mean that only those firms with a relatively large scale and/or sufficiently well-developed intellectual property or products can raise funds in this fashion. Between 1998 and 2001, established biotechnology centers accounted for the bulk of these initial public offerings. Three metro areas — San Francisco, San Diego, and Seattle — accounted for more than 60% of the IPOs during this period.

Firms Founded during the 1990s. Significant shifts have occurred during the past three decades in the pattern of biotechnology firm formation. San Francisco and Boston accounted for fewer than 20% of biotech firms founded prior to the 1980s, but about one-third of those founded in the 1990s. San Diego, Raleigh-Durham, and Seattle accounted for fewer than 10% of the firms founded prior to 1980, but nearly one-fourth of the firms founded in the 1990s. During the past two decades the founding of biotech firms appears to have become more concentrated into relatively fewer metropolitan areas. These five metropolitan areas accounted for a little more than 25% of biotech firms founded prior to 1980 but about 56% of the firms founded in the 1990s.

Conclusion

From an economic-development perspective, biotechnology is clearly a desirable industry. Although generally not among the largest employers in metropolitan economies, biotech firms have the potential to generate highly paid high-skill jobs. It is thus not surprising that as the industry's size and impact continue to expand, many regions across the United States are eagerly seeking to develop a biotechnology cluster. For some, this may mean building upon the early success of a few nascent firms. For others, it may mean working to expand a cluster that is already robust.

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